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A PRELIMINARY REPORT ON THE PRECOOLING AND TRANSPORTATION OF FLORIDA SNAP BEANS IN REFRIGERATOR CARS

By

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A Preliminary Report on the Precooling and Transportation of Florida Snap Beans in Refrigerator Cars [1]

It is well known that maintaining low temperatures during the transit period is important in the delivery of disease-free beans in a condition of garden freshness upon arrival at market. It is not so well known how effective these low temperatures can be in arresting the development of watery soft rot or white mold, a disease of increasing importance caused by the fungus Sclerotinia sclerotiorum. Shippers know from experience that standard refrigeration service is not effective in checking the development of watery soft rot, especially when shipments are made from diseased fields. This is doubtless due to the time required to reduce the beans to a temperature at which this rot-producing fungus is inactivated. The quicker the load is cooled, the less chance there is for spoilage to occur during the transit period. Although the causal fungus may grow at a greatly retarded rate at temperatures as low as 32°F., it has been shown that a temperature of 40°F. or below curbs the development of this fungus to such an extent that there is little spread of the rot from pod to pod and little development of decay in unwounded tissue. Accordingly it is to be expected that for ordinary transit periods, temperatures maintained between 40° and 45° will be generally satisfactory. To secure them, however, the beans must be precooled.

Experience with other commodities has shown that when the precooling is done with ice and bunker fans (a fan placed on the inside of the car at each upper bunker opening before the car is loaded, and removed after precooling) the bunkers must be kept well over half-full of ice to effect the most rapid cooling; the rate of cooling can be accelerated by the addition of salt to the ice. A commodity temperature of 40°F. or somewhat below can be obtained without much difficulty in light loads of well ventilated containers, when adequate air channels are left between the rows of packages. To maintain temperatures within the range of 40° to 45°F. during the transit period, the protective service supplied by the carrier, i.e., standard refrigeration or some modification thereof, such as initial icing plus one or two reicings in transit, can be specified, depending upon outside temperature conditions and the length of time the car is expected to be in transit.

With but few concrete data available on the precooling of snap beans, five preliminary tests, each differing somewhat from the others, were made during March, 1945. This was toward the end of the bean shipping season (in the Pompano district) and after the weather had become quite warm. At that time the beans were much warmer when loaded than they were a few weeks earlier. Hence, with more heat to be removed, the loads were more difficult to precool.

The objects of these tests were to determine (1) the approximate rate of cooling of snap beans in bushel hampers, using bunker fans and ice; (2) the relation of such precooling to commodity temperatures during the transit period, and (3) the

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[1] The tests were made in cooperation with the Growers and Shippers League of Florida and with Butts Farms, Inc., North Boca Raton, Florida.

comparative condition of precooled and non-precooled beans upon arrival at destination. All of the shipments were from Butts Farms, Inc., North Boca Raton, Florida. Four cars went to W. C. Deyo, N. Y., and two to F. A. Urie, Philadelphia, Pa.

In order to determine accurately the rate of precooling, ten electric resistance thermometers were placed in different parts of the load and, by means of a cable extending to the outside of the car, readings were made at frequent intervals during the precooling period without opening the car.

Three recording thermometers were used to obtain a continuous record of temperature from loading time in Florida until the cars were unloaded at the terminal markets. These were placed in test packages in each car and were located at the bottom bunker, middle quarter length, and top doorway positions which generally are, respectively, the coldest, the average, and the warmest positions. These same packages were likewise inoculated by placing a few pods infected with watery soft rot at two levels in the hampers to determine the rate of spread of the disease during transit. Results of the different tests will be summarized briefly.

Test 1 - MDT 4412. March 1, 1945. Preiced to full bunker capacity, precooled 24 hours, 29 minutes; reiced to capacity during precooling and again after precooling; shipped under rule 240 (no reicing in transit); unloaded at New York, March 8. There were several varieties in the commercial load; the test hampers contained wax beans.

This car was preiced well in advance of loading, and the bunkers were only about three-fourths full at completion of loading at 4:00 p.m. when the fans were turned on. The fans were operated almost continuously throughout the night and until all of the ice had melted. As shown by Figure 1 the average commodity temperature was 77° when precooling started. The fans were operated for six hours and the temperature was lowered to 60°. After this, due to the exhaustion of the ice, it was obvious that little was to be gained by operating the fans all night. However, when the bunkers were replenished to capacity the following morning the temperature dropped 15° more to 45°F. in about four hours. Due to this melting down of ice in the bunkers there was little if any additional reduction in temperature during the next four hours, thus again emphasizing the importance of keeping the bunkers full of ice, if precooling is to proceed at a satisfactory rate. During the precooling period the temperatures in different parts of the load were very uniform, the average for the top of the load being only a degree or two lower than the average of the middle, and bottom positions. This was due to the way in which the beans were loaded, which permitted good air circulation through the load. The bunkers were replenished at the end of the precooling period so that the car started out with bunkers fully iced.

Transit temperatures

The thermograph at the top doorway position failed to operate, but those at the middle quarter length and bottom bunker positions made continuous records (Fig. 2) throughout the transit period. The temperature at the middle quarter length position fell gradually for four days and levelled off at 42° for the remainder of the transit period; the temperature at the bottom bunker position fell rapidly for about 2-1/2 days and then leveled off at 37°F. These were very satisfactory transit temperatures. Bunkers were 1/4 to 3/8 full at time of unloading. The beans were in

good condition upon arrival in New York, and there was no spread of infection in the inoculated test hampers.

Test 2 - NP 90471. March 2, 1945. Preiced to full bunker capacity; precooled 11 hours, 40 minutes; reiced to capacity during precooling; shipped under standard refrigeration; unloaded at Philadelphia, Penn., March 11. There were several varieties in the commercial load; the test hampers contained Florida Belles.

This test differed from the first in three particulars: (1) The bunkers were almost full when precooling started; (2) fans were not operated between midnight and 8:30 a.m.; (3) the car moved under standard refrigeration.

The commodity temperature averaged 77°F. when the fans were started; after seven hours of continuous precooling the commodity temperature was reduced 24° and the fans were cut off at midnight. (Fig. 3).

The top commodity temperatures changed but little overnight and, since the ice had melted to such a low level by morning, the fans, which were turned on at 8:30 a.m. did not increase cooling until the bunkers had been replenished about two hours later. After reicing the average commodity temperature dropped 5° in three hours and was about 47°F. when the car rolled. The bunkers were replenished to full capacity before the car left the shipping point.

Transit temperatures

As shown in Figure 4 there was a drop of only a few degrees during the transit period, most of it taking place during the first three days of transit. From then on temperatures at the top doorway and middle quarter length positions remained about 42°F. The bottom bunker position reached its lowest level, 37°, some 24 hours after precooling was completed and remained practically unchanged to destination. Although this car moved under standard refrigeration, the commodity temperatures in it were quite similar to those in the first test car which moved under rule 240. At time of unloading the bunkers of this car were 3/8 to 1/2 full of ice. The beans were in satisfactory market condition and there was no spread of infection from the inoculated pods.

Test 3 - MDT 7259. March 21, 1945. Preiced to full bunker capacity; precooled 14 hours, 15 minutes; reiced to capacity twice during precooling; 150 lbs. salt added at 9:30 p.m. March 20, and again at 9:20 a.m. March 21; shipped under standard refrigeration; unloaded at New York March 28. Beans in the commercial load and test hampers were of the Plentiful variety.

This third test differed from the second mainly in that 150 lbs. of salt was added twice to the ice to increase the meltage and thus accelerate precooling. The beans averaged 74°F. at the beginning of precooling, but in less than four hours had dropped 23° (Fig. 5). During the shutdown period of slightly more than 9 hours the ice melted down to less than 1/4 of the bunker capacity, and a rise of 4° in commodity temperature took place. After replenishing the bunkers with ice and salt, and starting the fans again, the temperature was reduced from 55° to 39° in 8 hours and

20 minutes. By that time the ice had melted so much that there was a slight rise in temperature during the next and final two hours that the fans were operated. This indicates that unless the bunkers are reiced, there is no benefit from continued operation of the fans after the temperature starts to rise.

During the operation of the fans the top of the load had a temperature very close to the average for the load. The addition of salt to the ice resulted in more rapid cooling than was obtained in the previous tests; however, in judging this effect, the length of time the fans were operated should be kept in mind.

Transit temperatures

In spite of the fact that this car rolled under standard refrigeration, the top commodity temperature rose and the bottom fell somewhat during the early part of the transit period, but at no time was it above 43°F. (Fig. 6). This was because the precooling reduced the top part of the load to a level that could not be maintained by standard refrigeration service during transit in this kind of a car. The bunkers were 5/8 full of ice at time of unloading and as in previous tests the beans were in very good condition. There was no spread of infection.

Test 4 - BREX 74653. This car was equipped with Preco fans which can be operated to force air up through the ice bunkers and out over the top of the load. They can be operated for precooling by attaching a suitable motor while the car is stationary, and during transit by adjusting a friction drive wheel against the car wheel tread. In this test this fan system was not used for precooling but was operated during transit, the fan lever being placed at the "on" position when the car left on March 21. The car was preiced to full bunker capacity, precooled with bunker fans for 4 hours, 40 minutes the same as in earlier tests and reiced to capacity during the precooling period. It was shipped under standard refrigeration and unloaded in New York March 27. Beans in the commercial load and test hampers were of the Plentiful variety.

In this test precooling was begun before completion of loading, the fans being turned on when the doorway was yet to be loaded. At the beginning of the precooling period the beans averaged 78°F. After two hours of operation 50 lbs. of salt were added to each bunker causing the rate of cooling to be accelerated as shown in Fig. 7. During the first 3-1/4 hours of precooling the commodity temperature fell to 53°, a drop of 25°, but during the next 50 minutes while the fans were stopped and the doors opened for completion of loading, there was an appreciable rise in commodity temperature. This was not overcome by precooling for an additional 1-1/2 hours when precooling had to be discontinued because the pick-up train was due. Since this car was equipped with Preco fans, it was believed the commodity temperature would soon be reduced to a satisfactory level by operating the fans while the car was in motion. If this could be shown, it would demonstrate how a good deal of time could be saved in precooling, but because the fans do not operate when the car is standing still their effectiveness obviously depends upon the car being kept moving.

Transit temperatures

As shown in Figure 8 the temperatures dropped at a moderate rate during the first 2-1/2 days and thereafter gradually rose, especially at the top doorway. At time of unloading the bunkers were 4/5 full of ice. As in the earlier tests the beans were in good condition upon arrival.

Test 5 - SFRD 23486. March 22, 1945. Preiced to full bunker capacity; precooled 12 hours, 45 minutes; reiced to capacity during precooling; shipped under standard refrigeration; unloaded at Philadelphia, Penn., March 28. Beans in the commercial load and test hampers were of the Plentiful variety.

This test was similar to test 2 in that the bunker fans were operated in the evening, disconnected during the night, and turned on again in the morning. The beans averaged 66°F. when precooling started, but after six hours of continuous blowing the average temperature had fallen to 48° (Fig. 9). During the night when the fans were not running, (a period of about 12 hours) the average commodity temperature dropped 3° although at the top of the load the temperature rose 2°. After the bunkers were replenished in the morning and the fans were turned on, the commodity temperature dropped to 40° in 6-1/4 hours. Thus in this car 12 hours and 45 minutes of precooling were required to reduce the average temperature of the lading from 66° to 40°.

Transit temperatures

The temperature of the beans at the top doorway and middle quarter length positions rose a few degrees (Fig. 10) during the early part of the transit period in spite of two reicings and remained at about 42°F. during the remainder of the transit period. The bunkers were 4/5 full of ice at time of unloading. Upon arrival the beans were in satisfactory condition.

Test 6 - FGE 35611. March 24, 1945. Non-precooled, preiced to capacity 11:00 a.m. March 24, loaded in early afternoon; shipped under standard refrigeration; unloaded at New York March 29. Beans in the commercial load and test hampers were of the Plentiful variety.

This non-precooled car was used for comparison with the five cars that were precooled for various lengths of time. Four were shipped under standard refrigeration and were generally comparable except for precooling. The temperature of the beans in this car was in the 80's at the start and dropped slowly and steadily for about 4 days after which it leveled off in the range from 35° to 45°F. (Fig. 11). The temperature at the bottom bunker position fell most rapidly during the first 12 or 15 hours to about 47°, finally reaching 35° in 3-1/2 days, and remained at that level thereafter, about the same as in the precooled cars. However, at no time during the transit period did the beans at the top doorway and middle quarter length positions cool to the average at these positions in the four precooled cars shipped under standard refrigeration. In considering the temperatures in the various cars it should be kept in mind that it is not necessarily the level of these temperatures upon arrival that is important but rather the quick reduction to a satisfactory level (preferably before shipping) and their maintenance at that level thereafter. The bunkers of FGE 35611 were 7/10 full of ice at time of unloading. The beans were delivered in good marketable condition.

Discussion

Although the precooling operations differed somewhat in the various tests (due to unavoidable circumstances), the results followed the same general pattern. These tests showed that 640-hamper loads of beans stowed in the usual manner can be precooled satisfactorily at loading point by the use of ice in the bunkers and special precooling fans. The addition of salt to the ice accelerated the rate of precooling, but the rate was reduced as the ice melted down in the bunkers. Well over four hours of blowing was required to precool a loaded car satisfactorily.

Results in the one car that was precooled and shipped under rule 240 (the bunkers being replenished by the shipper) seemed to indicate that this would be a satisfactory procedure in cool weather, and if the time in transit were not more than seven days.

There was little if any difference in the condition of the beans in the several precooled cars on arrival at the market. All beans were fresh and crisp and generally in an excellent state of preservation.

The lading in the non-precooled car was not of quite as high quality at shipping point as that of the precooled cars, but it was in satisfactory condition on arrival. No watery soft rot was found, probably because by that late date the disease had largely disappeared from the fields following the onset of summer weather.

Little or no watery soft rot was found in the commercial loads or even in the test packages in which infected beans had been placed prior to shipping. However, the disease made some progress in the infected pods, even in test packages in the coldest part of the load. This growth was considerably more in the warmest locations, but even there it was not great enough to be of commercial significance during the time these cars were in transit. The importance of quickly precooling the commodity to a temperature around 40°F. and holding it at that level or somewhat lower throughout the transit period should therefore be apparent. It is the best insurance the shipper can take against the development of watery soft rot in market consignments. This protection is especially valuable when shipments are made from infected fields.

The use of Preco fan cars offers a possibility of shortening the precooling period enough so that beans can be harvested and shipped the same day. In these cars the precooling can be continued until the pick-up train arrives, and from that time on the car fans will operate whenever the car is in motion, and will reduce the commodity temperature provided the bunkers are kept fairly full of ice. However, the fans do not operate while the car is standing so that during transit their practical effectiveness is reduced whenever the car is not moving.

Although standard refrigeration can be expected to lower the commodity temperature more rapidly than modified refrigeration services such as Rule 240 which uses less ice, the rate of cooling is too slow, and it is possible for watery soft rot to make considerable headway in a non-precooled load. This is especially true in the upper part of the load which is the last to be cooled in conventional end-bunker refrigerator cars, unless the cars are equipped with Preco fans. If the latter are used, the top part of the load is the first to be cooled. The important point to strive for is

to get temperatures reduced quickly so that mold development will be arrested. For that reason beans from infected fields should be cooled as promptly as possible after harvest, and kept cool all the way to market. Temperatures in the range of 40° to 45°F. proved quite satisfactory in these tests.

Summary

From these tests it may be concluded that the usual 640-hamper carload of snap beans can be precooled to a safe temperature within a reasonable time after loading by the use of bunker fans and ice.

The results indicate that not less than ten or twelve hours of continuous blowing will be required and that the bunkers should be replenished at least twice during the precooling operation.

The addition of salt to the ice accelerates ice meltage and also the rate of precooling.

A temperature of about 40°F. quickly arrived at and maintained during the transit period is effective in checking watery soft rot.

Shipment of non-precooled beans under standard refrigeration without precooling does not reduce the commodity temperature fast enough to check watery soft rot. Precooling to 40°F. followed by standard refrigeration in transit is necessary to prevent rapid development of the causal fungus and losses from the disease.

Car No. N P 90471. Test 2. Initially iced Boca Raton, Florida, March 1, 1945, 1:45 p.m. 10,700 lbs. Re-iced Baldwin, Florida, March 4, 1:43 p.m. 4,800 lbs. Re-iced Aberdeen, N. C., March 5, 9:03 a.m. 1,900 lbs. Upon arrival in Potomac Yard, bunkers were more than 1/2 full of ice and in compliance with Interstate Commerce Commission Service Order 282 which prescribed that cars having ice in bunkers more than 1/2 full would not be re-iced, this car was not iced. Information furnished by Mr. Mills of the Fruit Growers Express Company.

Figure 1. TEMPERATURES WHILE PRECOOLING BEANS IN REFRIGERATOR CAR
Palm Beach County, Fla. - March 1-2, 1945
Bunker fans and ice
Fla. beans 1945-test 1
ART 4412 - 640 hampers

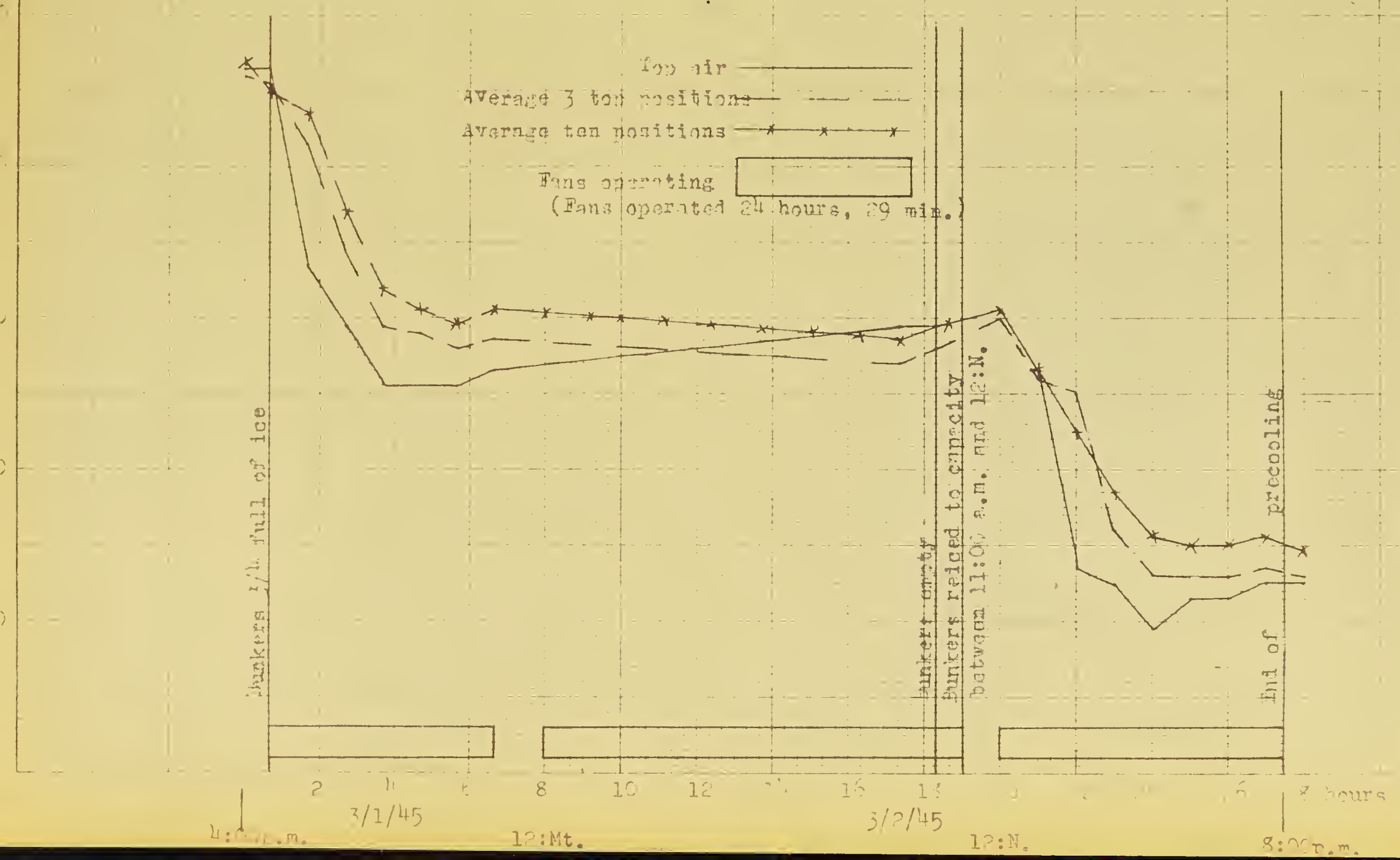


Figure 2.

TEMPERATURES IN TRANSIT
Palm Beach County, Fla.-N. Y. C. March 1-8, 1945.
Precooled bunker fans and ice, rule 240.
Fla. beans 1945-test 1
MDT 4412 - 540 hampers.

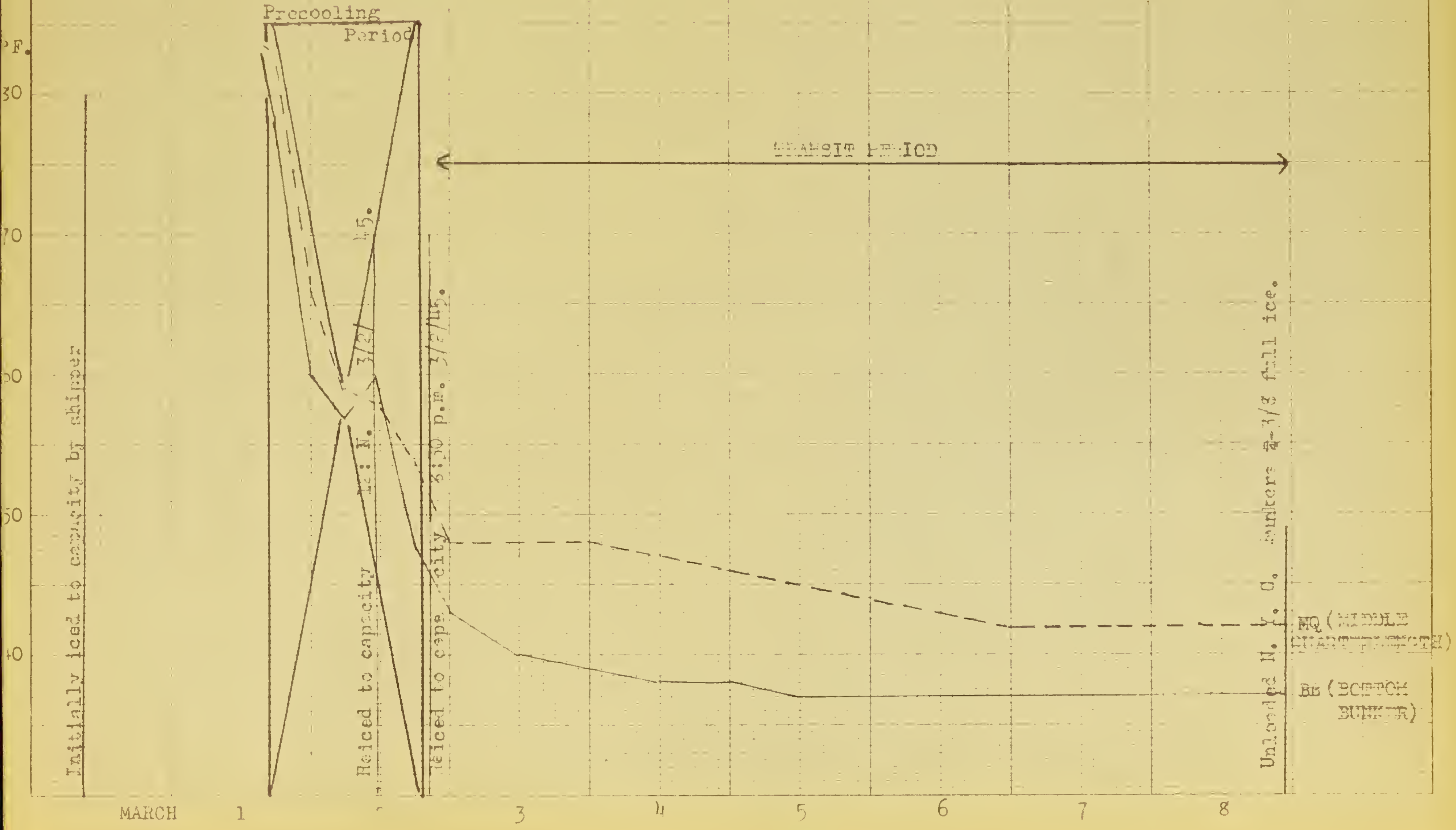
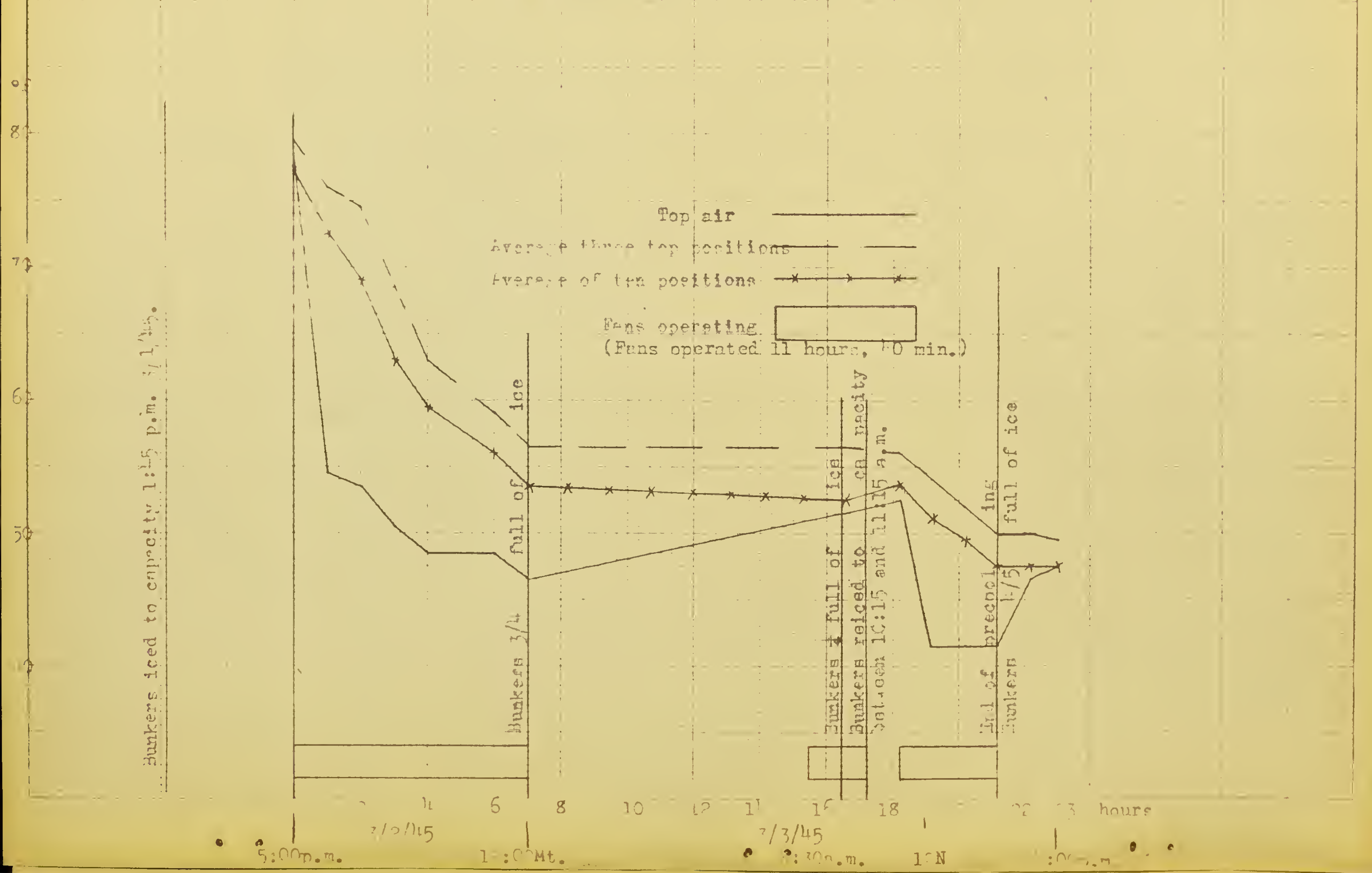


Figure 3. TEMPERATURES WHILE PRECOOLING BEANS IN REFRIGERATOR CAR
Palm Beach County, Fla.-March 2-3, 1945
Bunker fans and ice
Fla. beans 1945-test 2
NF 90471 - 683 hampers



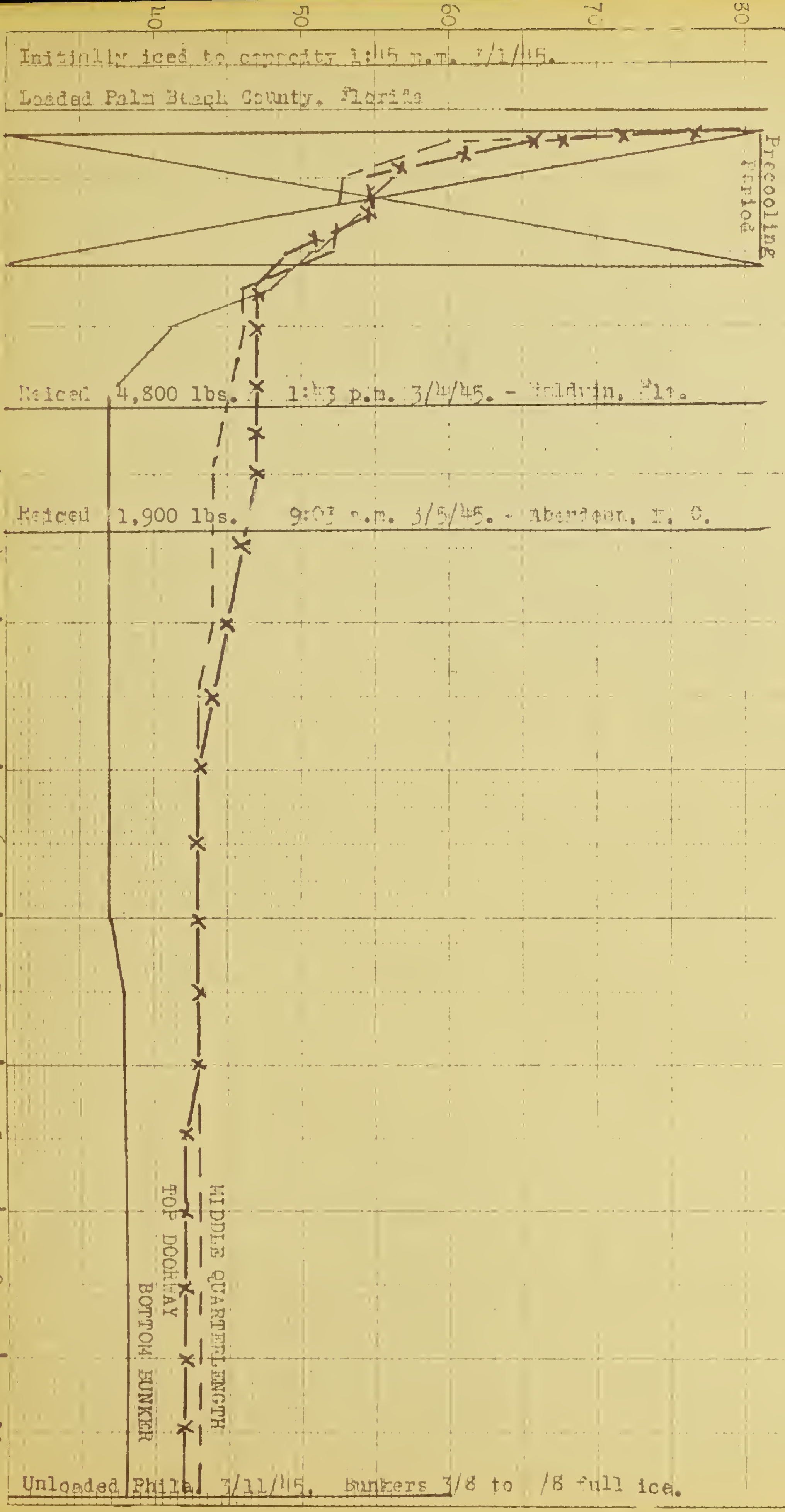


Figure 4. TEMPERATURES IN TRANSIT
Palm Beach County, Fla.-Phila. March 2-11, 1945.
Precooled bunker fans, preiced, standard refrigeration.
Fla. beans 1945-test 2
NP 90171 - 683 hampers.

Figure 5. TEMPERATURES WHILE PRECOOLING BEANS IN REFRIGERATOR CAR
Palm Beach County, Fla.-March 20-21, 1945
Bunker fans, ice, and salt
Fla. beans 1945-test 3
MDT 7259 - 640 hampers

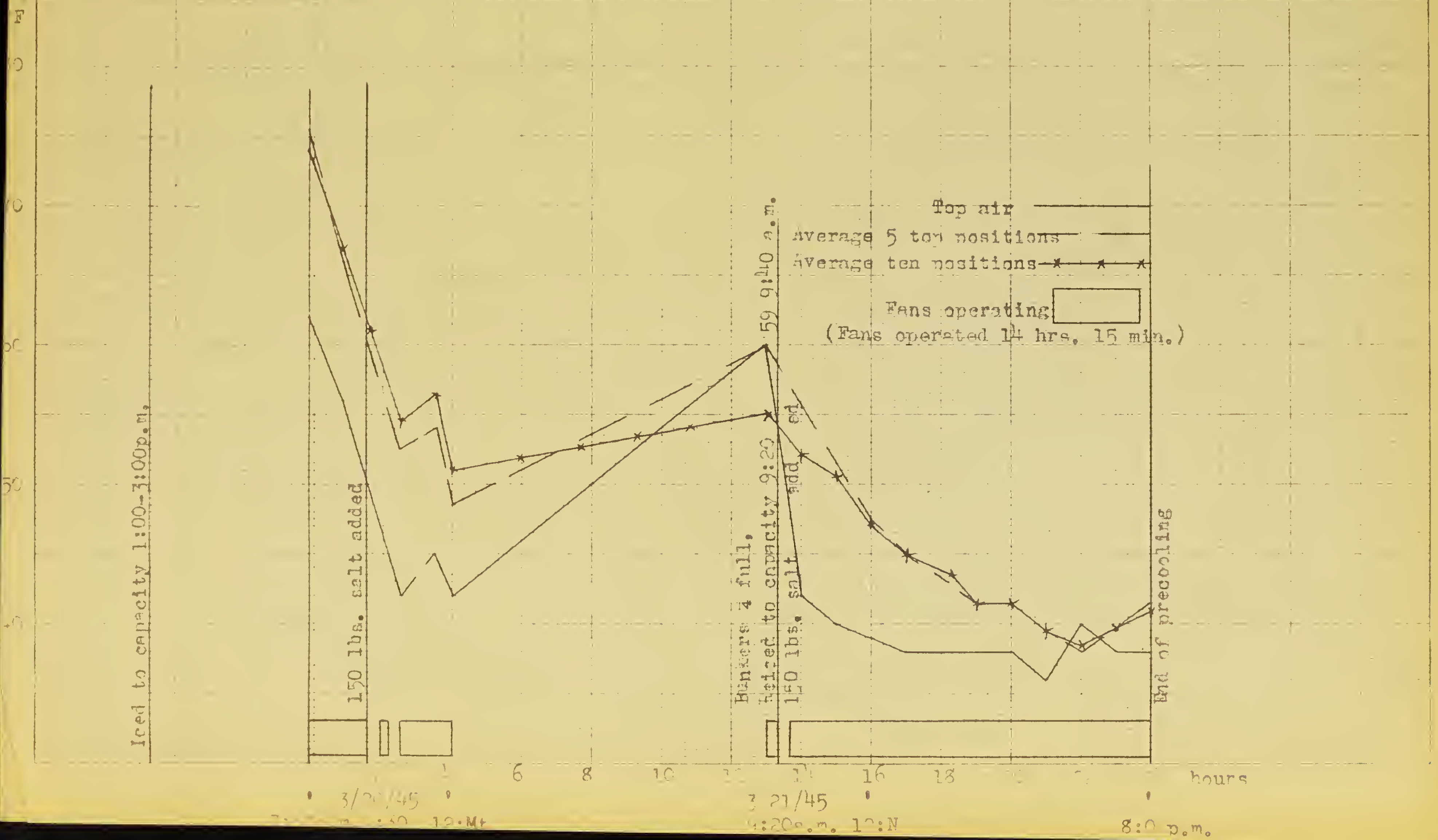


Figure 4. TEMPERATURES IN TRANSIT
Palm Beach County, Fla.-N. Y. C. March 20-28, 1945.
Precooled with bunker fans, ice and salt, standard refrig.
Fla. beans 1945-test 3
EDT 7259-440 hampers.

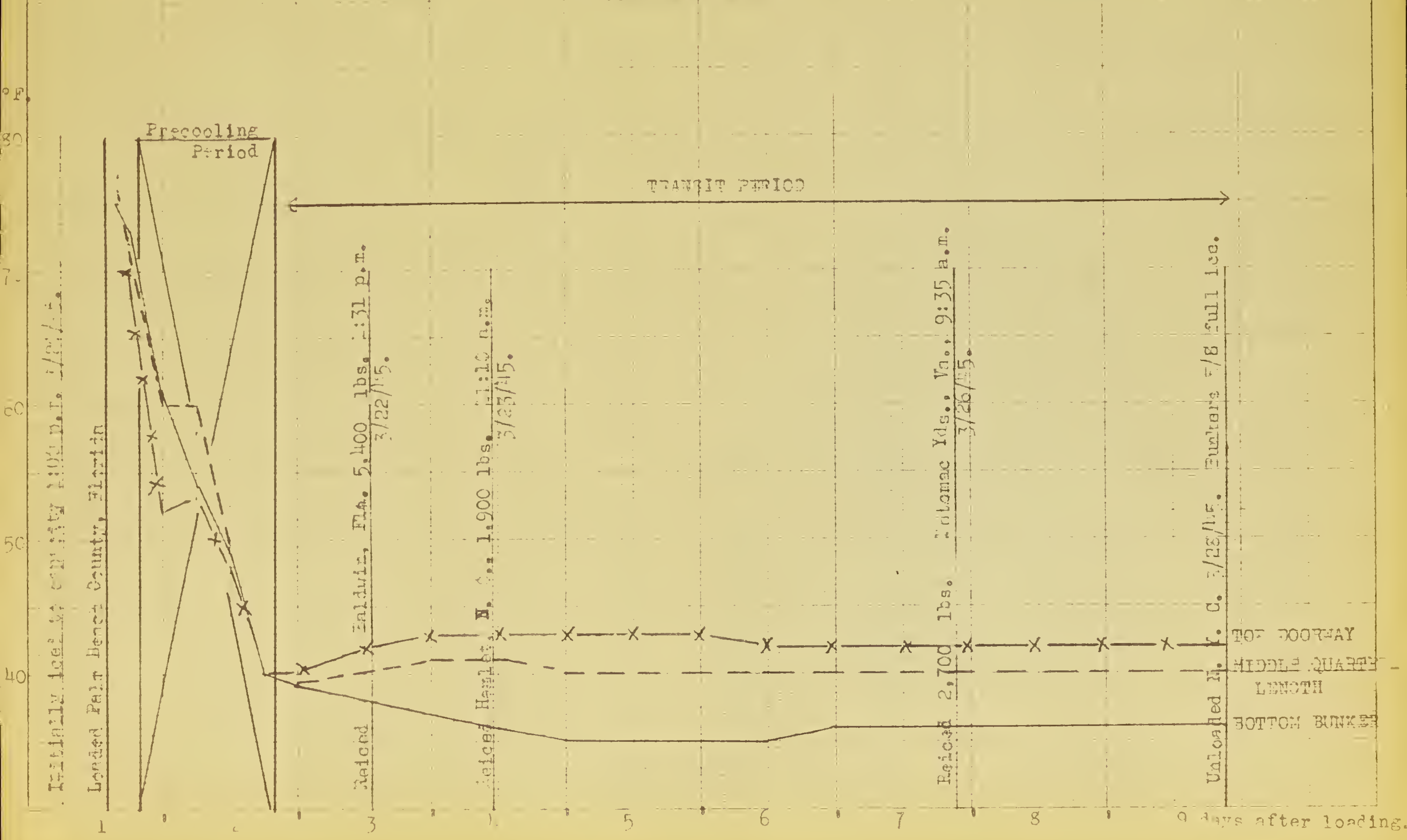


Figure 7. TEMPERATURES WHILE PRECOOLING BEANS IN REFRIGERATOR CAR
Palm Beach County, Fla. - March 21, 1945
Bunker fans, ice, and salt
Fla. beans 1945-test 4
BRE 74653 - 640 hampers.

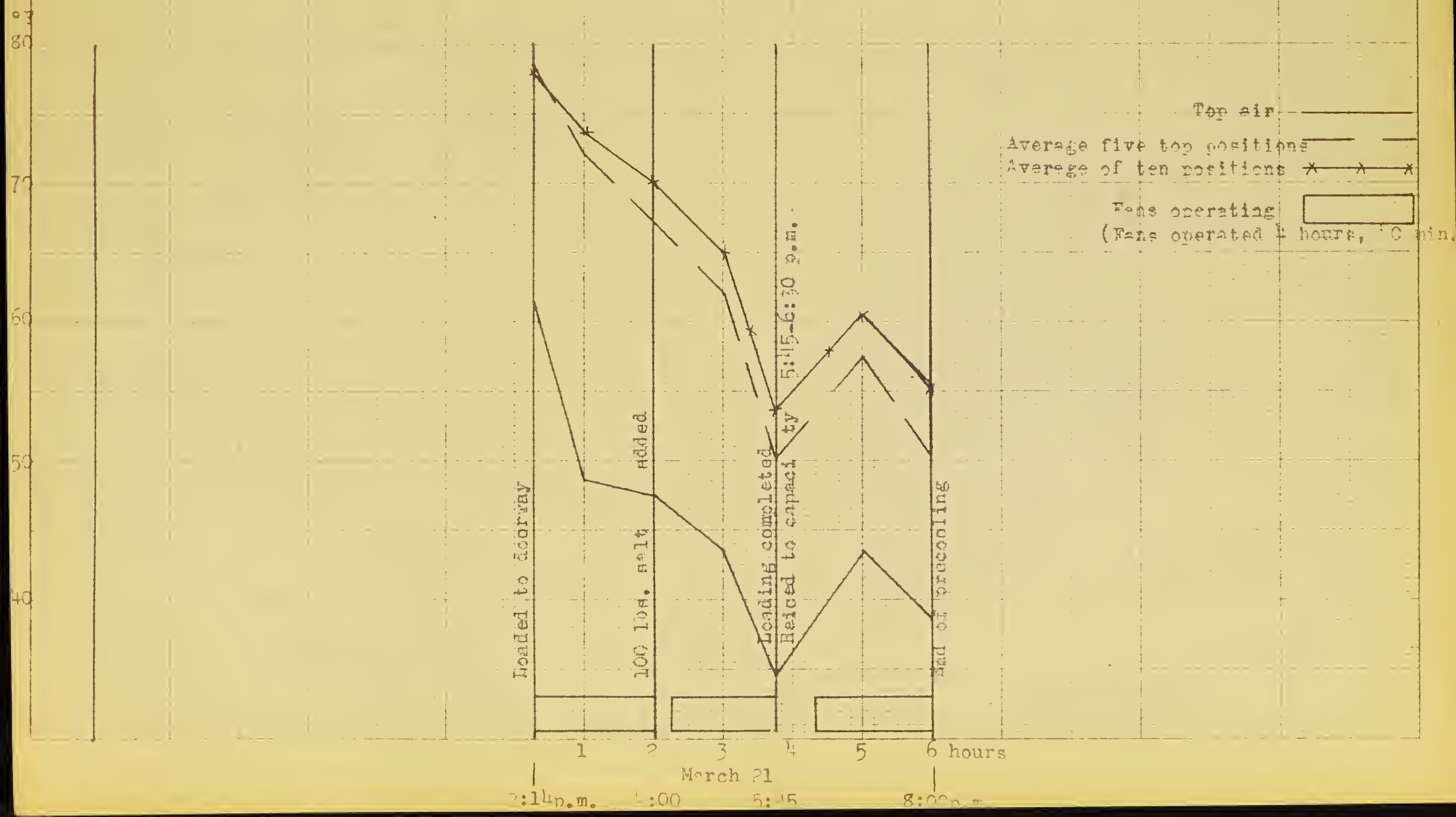


Figure 8. TEMPERATURES IN TRANSIT
Palm Beach County, Fla.–N. Y. C. March 21-27, 1945.
Precooled with bunker fans, ice, and salt, preiced, std. refrig.
Fla. beans 1945-test 4
ART 74653 - 640 hampers.

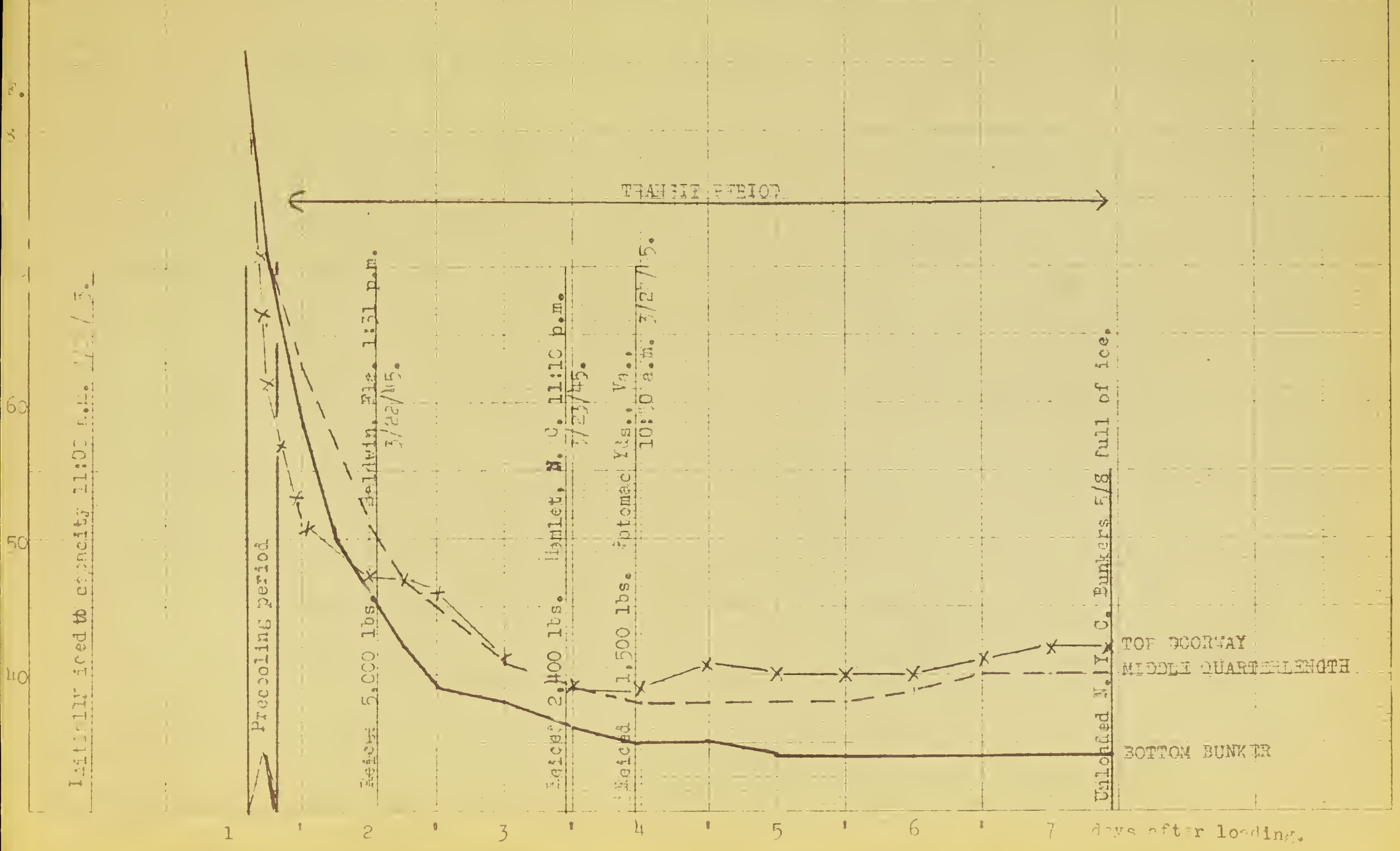


Figure 9. TEMPERATURES WHILE PRECOOLING BEANS IN REFRIGERATOR CAR
Palm Beach County, Fla. - March 22-23, 1945.
Bunker fans and ice.
Fla. beans 1945-test 5
SFRD 23486 - 640 hampers.

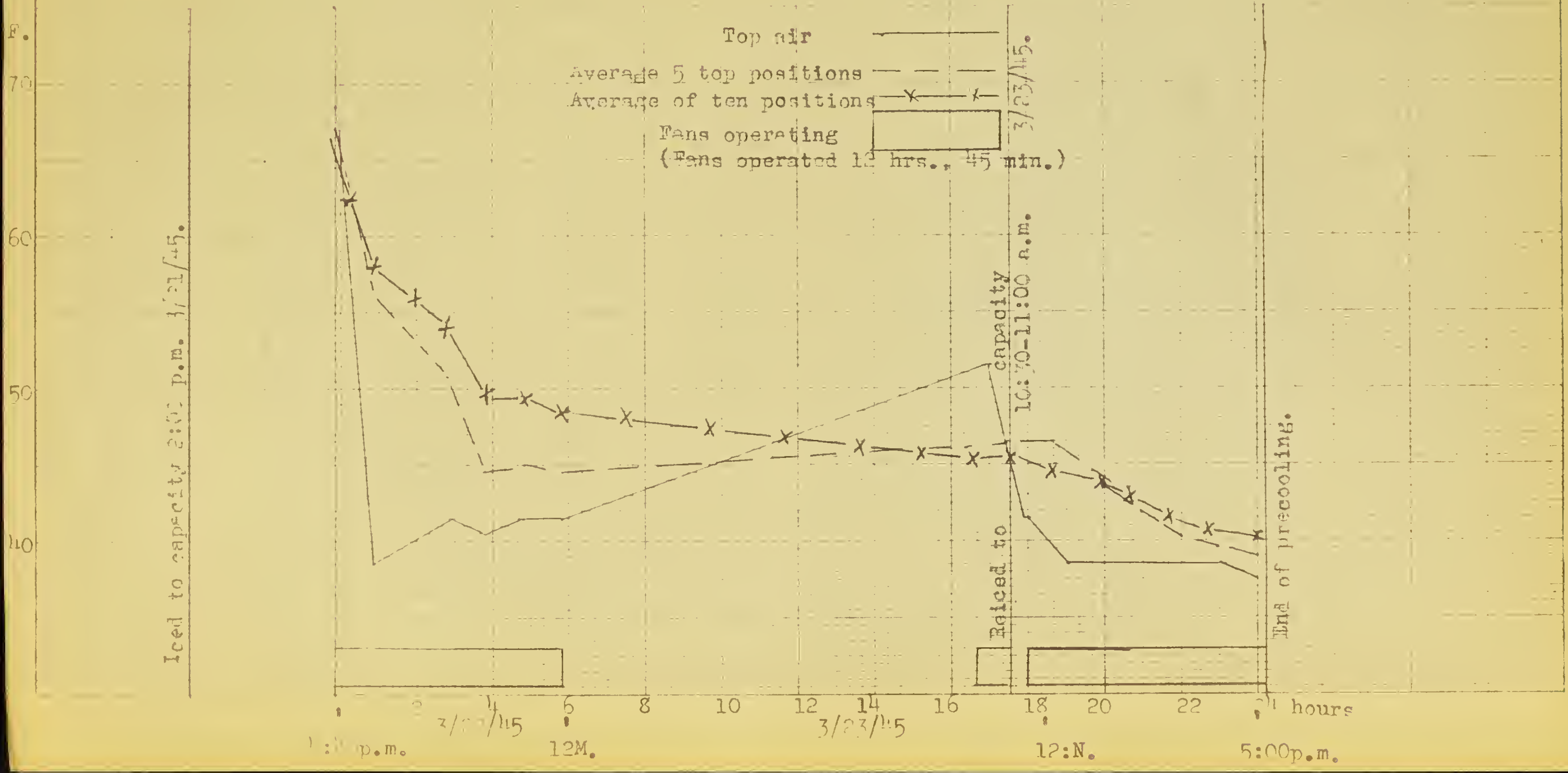


Figure 10. TEMPERATURES IN TRANSIT.
Palm Beach County, Fla. - Phila. March 21-29, 1945.
Precooled with bunker fans and ice, standard refrig.
Fla. beans 1945-test 5
SFRD 23436 - 640 hampers.

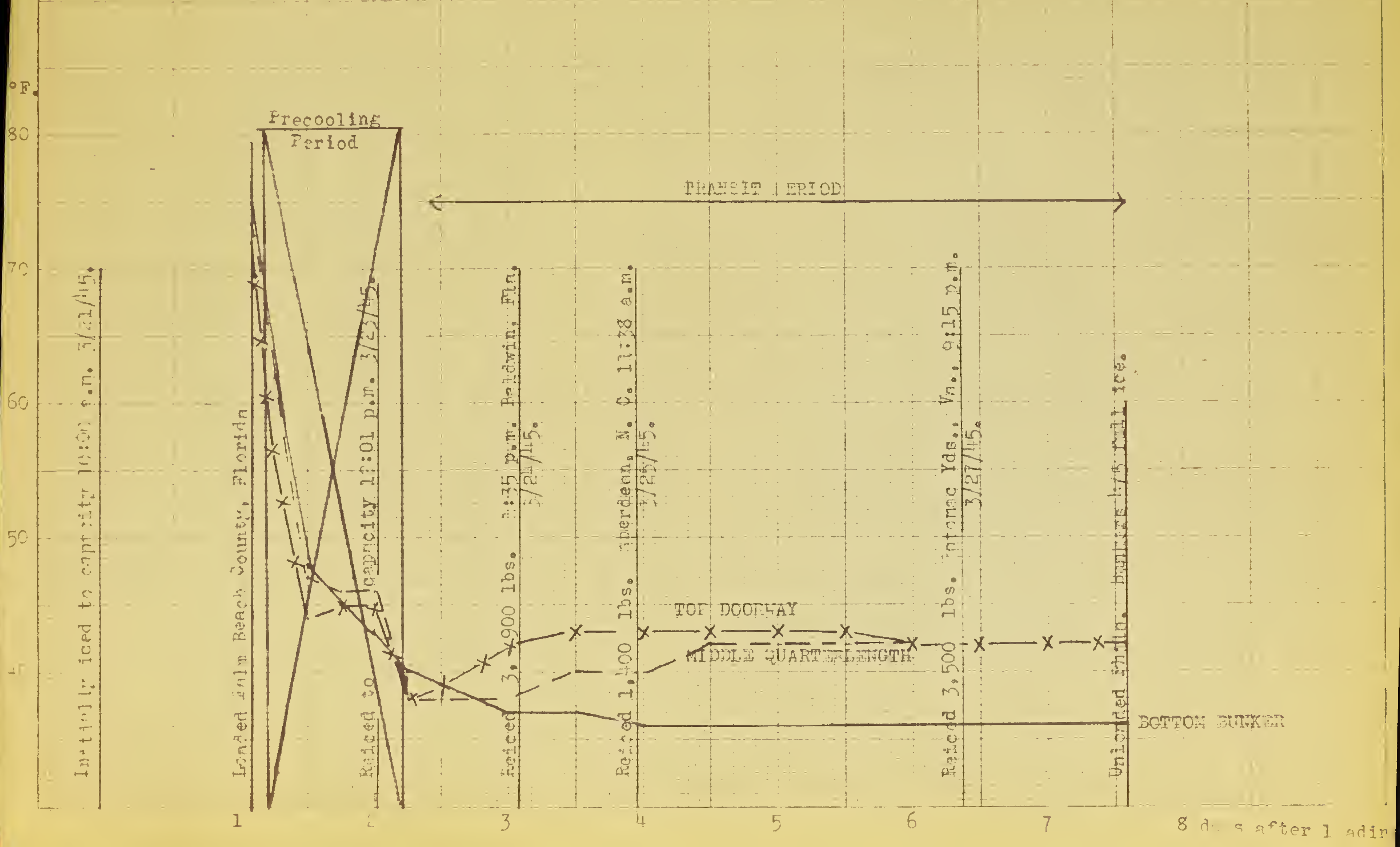
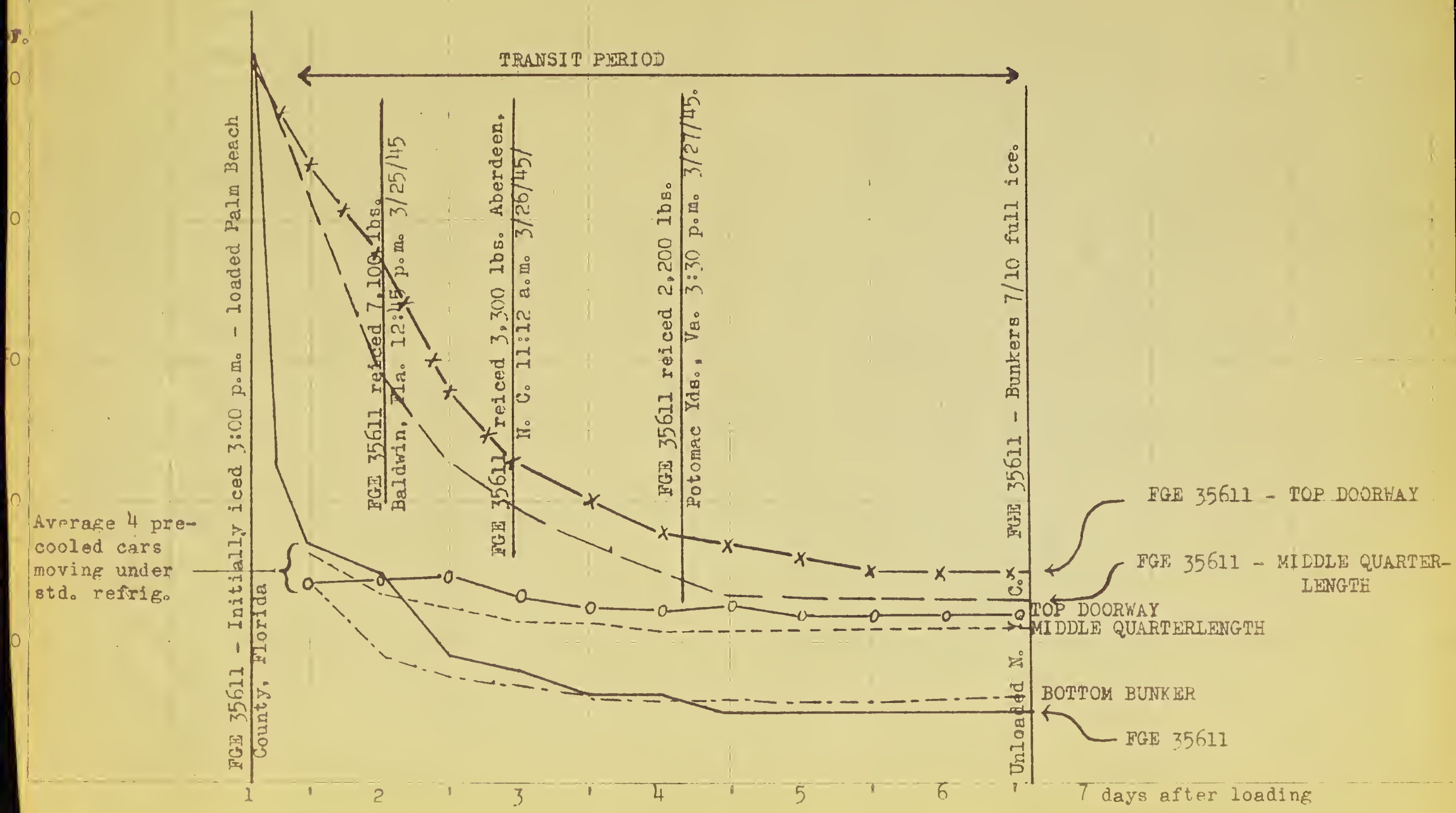


Figure 11. TEMPERATURE IN TRANSIT
Palm Beach County, Fla. - N. Y. C. or Phila.
FGE 35611 - Non-precooled, preiced, std. refrig. - 3/24/45-N. Y. C. Fla. beans 1945-test 6
640 hampers

Compared with average of four precooled cars, moving under standard refrigeration.


F.
TRANSIT PERIOD
FGE 35611 - Initially iced 3:00 p.m. - loaded Palm Beach County, Florida
FGE 35611 reiced 7,100 lbs. Baldwin, Fla. 12:45 p.m. 3/25/45
FGE 35611 reiced 3,300 lbs. Aberdeen, N. C. 11:12 a.m. 3/26/45
FGE 35611 reiced 2,200 lbs. Potomac Yds., Va. 3:30 p.m. 3/27/45.
FGE 35611 - Bunkers 7/10 full ice.
Unloaded N. Y. C.
Average 4 precooled cars moving under std. refrig.
FGE 35611 - TOP DOORWAY
FGE 35611 - MIDDLE QUARTER-LENGTH
TOP DOORWAY
MIDDLE QUARTERLENGTH
BOTTOM BUNKER
FGE 35611
1
2
3
4
5
6
7 days after loading